

contaminations, is not acceptable because of the potential health hazards from chemical residues. To resolve the problem, the FDA has established maximum levels for such defects in food produced under good manufacturing and/or processing practices and uses these levels for recommending regulatory actions. Currently, the government has published a list of "defect action levels," stating the amounts of contamination which will subject the food to enforcement action. Such food defect action levels are set on the basis of no hazard to health and are changed from time to time. Any products which might be harmful to consumers are subject to action based on their health hazard, whether or not they exceed the "defect" levels. The mixing of food to dilute contamination is prohibited and renders the product illegal regardless of any defect level in the final product.

Defect action levels are established for products whenever it is necessary and feasible. Such levels are subject to change upon the development of new technology or the availability of new information.

Compliance with defect action levels does not excuse failure to observe either the requirement that food may not be prepared, packed, or held under insanitary conditions or the other requirements that food manufacturers must observe current good manufacturing practices. Evidence obtained through factory inspection indicating such a violation renders the food unlawful, even though the amounts of natural or unavoidable defects are lower than the currently established action levels. The manufacturer of food must at all times utilize quality control procedures which will reduce natural or unavoidable defects to the lowest level currently feasible.

The mixing of a food containing defects above the current defect action level with another lot of food is not permitted and renders the final food unlawful regardless of the defect level of the final food.

**Food Action Levels.** Action levels for poisonous or deleterious substances in human food and animal feed are established by the FDA to control levels of contaminants. Action levels and tolerances represent limits at or above which FDA will take legal action to remove adulterated products from the market. Where no established action level or tolerance exists, FDA may take legal action against the product at the minimal detectable level of the contaminant. Action levels and tolerances are established based on the unavoidability of the poisonous or deleterious substance and do not represent permissible levels of contamination where it is avoidable.

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## SAUSAGES

Sausages are a diverse group of foods made from ground or comminuted meats, salt and spices. They originated during prehistoric times when our ancestors discovered that addition of salt and drying would delay spoilage. Adding various spices improved palatability and stuffing them into intestines enhanced convenience. Homer mentions sausages in the *Odyssey* and the word, sausage, come from Latin meaning salted or meat preserved by salting. Over the centuries virtually every culture developed distinctive sausages depending on their live stock, spices, climate, and culture. The European origin of most of our sausages is indicated by the city names associated with them: Bologna, Genoa, Braunschweig, and Thuringen. Dried sausages originated in southern Europe where warm climates required a more spoilage-resistant sausage. Northern Europeans, having a cooler climate, created cooked and summer sausages. Americans contributed Lebanon bologna and the popularization of the hot dog.

Sausages are an excellent source of high quality proteins. In addition, they contribute iron, zinc, and B vitamins, particularly folic acid, B<sub>6</sub> and B<sub>12</sub>. Controversy has existed over the addition of nitrite and possible subsequent formation of nitrosamines, sodium content and fat levels, especially saturated fats.

Americans manufactured 6.0 billion pounds of sausages in 1987, 10% of the total amount of all red meats. Frankfurters amounted to 1.5 billion pounds, bologna 640 million, uncooked cured sausages 24 million, dried and semi-dried 445 million, liver sausages 96 million, loaf products 1.3 billion, and other sausage and loaf products 1.0 billion pounds. Poultry based luncheon meats totaled 151 million pounds and poultry frankfurters were 280 million pounds.

Classification of sausages is not clear cut because of the many variations in materials, spices and processes used. Meat is ground or finely chopped (comminuted) and mixed with salt and spices. It may have curing salts added and may then be stuffed, smoked, cooked, fermented, or dried. The United States Department of Agriculture classifies sausages as fresh; uncooked-smoked; cooked-smoked; cooked; dry/semi-dry; and luncheon meats, loaves, and jelly products.

Fresh sausages are made from uncured (no nitrate or nitrite added) meats, usually pork. They are ground and mixed with salt and spices, then stuffed into casings, natural casings or manufactured casings. They have a limited shelf-life even when refrigerated and must be cooked before serving.

Uncooked-smoked sausages (country-style sausage and kielbasa) are usually cured, require refrigeration for preservation and are cooked before serving.

Cooked-smoked sausages (frankfurters and bologna) are cured and cooked in casings inside a smokehouse. When properly refrigerated they have a long storage life and do not require final cooking by the consumer.

Cooked sausages (liver sausage and Braunschweiger) may be cured and are usually comminuted, seasoned, stuffed, and cooked. They are generally consumed cold.

Dry/semi-dry sausages utilize bacteria to ferment sug-

ars into lactic acid. This increases the sausages' acidity and contributes to their characteristic flavor and to their bacterial preservation. They are then dried to varying extents. These sausages do not need cooking before serving. Semi-dried sausages (summer sausages, cervelat, thuringer) need refrigeration for optimal storage. Dry sausages (hard salami, Genoa salami and pepperoni) need little or no refrigeration. Lebanon bologna is fermented and smoked but not appreciably dried.

The category of luncheon meats encompasses a wide variety of popular products. Typically a mixture of chopped meats with extenders and other ingredients is processed into a loaf form. Pimento loaf, olive loaf, and honey loaf are examples. Also included in this group are sandwich spreads, which are cooked, soft mixtures packaged in chubs. Jellyed products, such as jellyed tongue, souse and head cheese, consist of chunks of cooked and cured meats held in a loaf form by gelatin.

## INGREDIENTS

### Meats

Beef and pork are the primary meats, but goat and sheep are used by several cultures and fish sausages are consumed in the Orient. Poultry luncheon meats and frankfurters are increasing in popularity. Skeletal muscle has the highest binding and water holding properties compared to other meats and non-meat extenders. Other meats (lips, tripe, cardiac muscle), variety meats (tongue, livers, pork stomachs, etc) and mechanically deboned meats must be labelled if used. Pork trimmings and back-fat are important ingredients, because too little fat results in a dry, unpalatable product. Maximum levels of fat for different sausages are regulated by the U.S. Department of Agriculture; for example, frankfurters must have less than 30% fat.

### Salt

Salt is necessary for extracting the meat proteins to bind fat and water and to form the sausages' texture. Salt also contributes to the sausages' flavor and retards microbiological growth. Most sausages contain 2.5 to 3.0% salt, although fresh sausages contain only about 0.75%. To reduce the sodium content, potassium chloride may be substituted for salt (sodium chloride). The practical limit to the amount of potassium chloride that can be added is half of the total salt because of the bitter taste of the potassium. Addition of phosphates is another way to improve the binding and water holding of the proteins. Pyrophosphates, tripolyphosphate, and metaphosphates may be added to a combined maximum of 0.5%.

### Curing Salts

Originally part of natural salts, sodium and potassium nitrate and nitrite causes formation of the cured meat color and flavors. The nitrate is converted by naturally occurring bacteria to nitrite, which in turn forms nitric oxide. This binds to the heme iron of myoglobin to form the pink color of cured meats. Nitrite also contributes to

the flavor of cured meats and retards rancidity. Nitrite inhibits the outgrowth of *Clostridium botulinum* spores; growth of these bacteria can produce a potentially fatal toxin. Nitrite addition is strictly limited because of the potential for formation of mutagenic nitrosamines. Use of sodium ascorbate or erythorbate prevents formation of nitrosamines by competing with secondary amines for nitrite, speeds the curing reactions, and stabilizes the cured meat color.

### Spices

The flavor of a particular sausage is strongly dependent on the spices added; every sausage maker has a special mixture. Sage gives the flavor to fresh breakfast sausages; white pepper, mustard, coriander and nutmeg flavor frankfurters; garlic is added to Italian sausages; and cayenne pepper, paprika and garlic flavor pepperoni.

### Sugars

Sucrose (common sugar), dextrose, corn syrups, or sugar derivatives may be added to many sausages. About 1% is necessary in fermented sausages for growth of the lactic acid bacteria. Sugars contribute to the flavors by their sweetness, participation in browning flavors, and masking (mellowing) the saltiness.

### Water

Often added as ice to chill the meats, addition of water permits more efficient chopping and mixing, aids in dissolving the salts, and improves the fluidity of the mixture for proper filling of the casings. The texture of sausages is greatly enhanced by having the proper amount of moisture.

### Additives

Acidulents, such as glucono-delta-lactone, are occasionally added to increase the acidity rapidly. This accelerates the curing reaction in quickly processed products such as frankfurters, or controls the growth of undesirable microorganisms in fermented sausages until fermentation occurs. Soy proteins, milk proteins (casein and whey), yeast protein, flours, and starch are permitted in limited amounts in some sausages where they improve emulsion stability, fat and water binding, flavor, cooking yield, and textural characteristics. Antioxidants to retard rancidity and mold inhibitors are added to some products. All of these additives must be declared on the label if they are used.

## PROCESSES

### Grinding and Comminuting

The meat for fresh and fermented sausages is ground through a grinder and then mixed with salt and any other ingredients. Some loaf and luncheon meat products use chunks of meat bound together by the extracted meat proteins that coat the surface after mixing with salt and water.

## SAUSAGES

Frankfurters and bolognas are comminuted or finely chopped with the salt and ice to extract/solubilize the proteins. Then the fat and remaining ingredients are added and chopped further to form a smooth batter.

### Casings

The sausage mixture or batter is stuffed into casings of various types, sizes and shapes for further processing, storage, and consumer convenience. Originally natural or animal casings made from stomachs, intestines and bladders of cattle, hogs and sheep were used, and are still associated with many traditional, high quality sausages. They are in limited supply and highly perishable. They are less uniform in size, more fragile and require more care during stuffing than manufactured casings. The latter are either cellulose from cotton linters (cotton by-products) or collagen from the corium layer of beef hides. Cellulose casings are available in many sizes, strengths, and properties. Small types are used to cook frankfurters in a smokehouse and then removed before packaging. Large fibrous cellulose casings, which remain on luncheon meats and fermented and dried sausages, are removed by the consumer. Small collagen casings can be consumed and are used for breakfast and other uncooked sausages.

### Stuffing and Linking

The sausage mixtures and frankfurter batters can be pumped through stuffers by either impeller or piston pumps. The casings are placed over a stuffing horn and the sausage extruded into the casing. Links are formed by twisting the casing or by using string ties or metal clasps.

### Fermenting and Drying

Originally the bacteria for fermented meats were natural contaminants of the meats, equipment and facilities. Small amounts of successfully fermented products were often added back to new batches to start the fermentation. Most manufacturers now add cultures of selected bacteria and a fermentable sugar and then hold the mixture at 70–82°F and 80% relative humidity for 2–3 days to ensure a desirable fermentation. The bacteria produce lactic acid which gives the sausages their tangy flavor and reduces the pH to 4.6–5.4, aiding preservation. The cured color also forms at this time. The sausages then go into the drying room where they are held at 45–55°F and 69–72% relative humidity. Semi-dry sausages are dried for 10 to 21 days and contain 50% moisture. Dry sausages are dried for 60 to 120 days and contain only 35% moisture.

### Smoking and Cooking

Smoke is no longer as important as a preservative, but it contributes to flavor, color, and microbial preservation. Controlled burning of hardwood chips produces a mixture of organic acids, carbonyls, and phenols. The acids cause surface coagulation of the proteins forming a skin on the product. Carbonyls contribute a brownish color and phenols plus some carbonyls add the smoke flavors. Many continuous and large volume processes use an aerosol of liquid smoke which is more consistent and easier to use. It may also be added directly as a flavoring or applied to the

surface. In addition, liquid smoke does not contain any of the carcinogenic polycyclic compounds that may be formed if the burning temperatures are too high.

Frankfurters are smoked during the beginning of a cooking sequence. The temperature is raised in steps with humidity control and good circulation until the internal temperature reaches 155–160°F. The frankfurters are then showered with cold water to cool.

### Packaging

Most sausages are sold in the casings they were stuffed into. Frankfurters, however, are stripped of the cellulose casing after cooking in the smokehouse. Many sausages are vacuum packaged to extend shelf life by preventing water loss, retarding oxidation, and slowing microbial growth.

### Developments

Sausages continue to have great popularity because of their appealing flavor and convenience. The increasing variety available in the retail stores reflect consumer interest in convenience and specialty foods. Salt levels have been reduced although many sausages still contain high amounts of sodium. Research is underway to reduce or replace the animal fat while retaining the expected flavor and textural feel of the products. Meat inspection and quality assurance programs are under revision as the inspection agencies include more microbial and residue testing with the traditional visual inspection. Hazard analysis-critical control point (HACCP) procedures are particularly important in controlling pathogenic microorganisms such as *Salmonella*, *Staphylococci* and *Listeria*.

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## SEAFOODS: FLAVORS AND QUALITY

### BACKGROUND

With few, but important, exceptions the majority of seafoods are relatively mild in flavor intensity when compared to foods prepared from beef, poultry, pork and lamb.